Radiation Physics Note 95

Transfer Calibration of Radioactive Sources used in Instrument Calibration

12/28/89 (preliminary)

5/4/92 (final)

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Introduction

This note documents a series of tests performed at various times to quantify the exposure rate from various ^{137}Cs gamma ray sources used in instrument calibration by the Radiation Physics Technical Support Group of the Environment, Safety, and Health Section at Fermilab.

The six ^{137}Cs wand mounted sources used by The Instrument Maintenance And Calibration Team (IMAC) prior to 1987 for calibration of Fermilab health physics instruments were originally calibrated in 1972 by transfer calibration with a member of this group of sources possessing NBS certification[1] (137-5.4-2). This was performed using a well-type ionization chamber and a Keithley electrometer. Specific information on this study is unfortunately not available.

Due to the lack of information and the time elapsed since the 1972 transfer calibration, a study was undertaken to examine the existing sources, make substitutions and/or additions as deemed necessary, and perform a transfer calibration referenced to recently acquired NIST (NBS at the time) certified sources. These two ^{137}Cs sources (5mCi and 500mCi), in ICN 376 capsules, were purchased in 1982 and subsequently calibrated by NIST[2,3]. These are retained, in the Radiation Physics Calibration Facility (RPCF) at Site 38, for use as Derived Standards[4].

Analysis

Physical examination of the six original IMAC ^{137}Cs calibration sources revealed encapsulation differences. Four of the six sources are contained in ICN type 376 gamma capsules; and two in Atomchem type 2000, model CS2-4 capsules. The two Atomchem sources had been modified with a spacer to be of equal length to the type 376. A slit collimator check of the source capsules revealed differing source positions, within the capsules, between the two capsule types. It is

desirable to provide a reproducible IMAC table collimator beam cross-section, thus standardizing on a single source capsule geometry appeared necessary.

Source acquisitions and transfers were made to improve the IMAC calibration source inventory. Type 376 encapsulated sources were procured from ICN to replace the two Atomchem sources (137-3.3-1 and 137-4.3-1). Additionally, a 70mCi source was procured to fill a large gap in the range of IMAC calibration sources, and the 600mCi 137-5.6-1 was transferred, from dosimeter calibration to IMAC, for table calibration to 2 R/hr. The 500mCi Derived Standard presently performs double duty as the dosimeter calibration source.

Calibration

Prior to placing the new sources in use, a transfer calibration was undertaken in the site 68 2nd floor calibration room, on the 1 meter calibration fixture. This study was performed with a Victoreen 540 R-Meter and model 130 (0-250mR) chamber, and a Dosimeter Corporation STRAD (0-2mR) used as Transfer Instruments[4]. Both instruments are air equivalent ion chambers, requiring correction for atmospheric pressure and ambient temperature. Initially, calibration factors for ^{137}Cs were determined for the STRAD and the R-Meter by irradiating the instruments with the 5mCi and 500mCi Derived Standard sources. Specific handling procedures for the STRAD and R-Meter are described in RP Note 89[5]. Multiple runs (5 - 10) were performed for each source calibration or standardization. Statistical analysis was subsequently performed for each set of measurements[5]. The smaller sources were calibrated with the STRAD, the larger sources with the model 130 R-Meter, and the 137-4.7-1 with both devices. The results of the two 137-4.7-1 calibrations were: used to check for response differences between the transfer instruments (<1%); and averaged for the 137-4.7-1 calibration.

The exposure rate for each source at 1 meter was determined for the day or median day performed. These values were then decay corrected back to April 1, 1987; the new reference date for the IMAC source calibration program.

Background measurements were made daily during STRAD standardization and calibration runs. This background was subsequently subtracted from the STRAD measurements prior to correcting for the chamber calibration factor.

The results of the transfer calibration shown in Table 1 below also contain the calibration of the projector facility sources (137-6.1-1, 7.1-1, and 8.1-1). This calibration was performed in 1984 following reconstruction of the source projector facility at Site 68. Multiple measurements were made with the model

130 R-Meter, on the detector carriage, at a 1 meter distance, for each source (Consult RP Note 51 for specifics.)[6]. Due to geometry differences between the 1 M fixture and the projector facility (location and source configuration) the Model 130 R-Meter was used as the Derived Standard[7] for this set of measurements. Data analysis (average and errors) was performed per reference 5.

Table 1

Calibration of Cs-137 Sources Used in IMAC Source Calibration Excel File

Source I.D.	Calibration Date (M/D/Y)	Dose Rate @ 1 M on Cal. Date (mR/hr)	Transfer Instrument	Derived Standard Reference	Dose Rate @ 1 M on Ref. Date (1) (mR/hr)	Estimated Error (%)
137-2.2-1	10/1/87	0.060	STRAD	137-3.5-1	0.061	8.7
137-3.1-1	7/2/87	0.254	STRAD	137-3.5-1	0.256	3.3
137-3.2-8	7/15/87	0.781	STRAD	137-3.5-1	0.786	3.3
137-3.5-1	8/9/87	1.394	STRAD	NBS (2)	1.41	0.9
137-3.8-1	6/17/87	1.679	STRAD	137-3.5-1	1.69	2.7
137-4.2-1	7/1/87	7.811	STRAD	137-3.5-1	7.86	3.2
137-4.7-1	8/6/87	24.650	STRAD	137-3.5-1	24.8	2.7
137-4.7-1	8/4/87	24.420	130 R-METER	137-5.5-1	24.6	2.1
137-4.7-1	N/A	N/A	STRAD/R-METER	3.5 & 5.5 Ave	24.7	2.4
137-5.4-2	7/31/87	84.930	130 R-METER	137-5.5-1	85.6	2.1
137-5.5-1	6/18/87	134.520	130 R-METER	NBS (3)	135	0.9
137-5.6-1	6/23/87	151.890	130 R-METER	137-5.5-1	153	2.1
137-6.1-1	9/26/84	457	N/A	130 R-METER	422	1.7
137-7.1-1	9/25/84	3590	N/A	130 R-METER	3320	1.9
137-8.1-1	9/13/84	28200	N/A	130 R-METER	26000	1.7

Table Notes:

1. Reference calibration date for IMAC program: 4/1/87
2. 137-3.5-1 was 1.56 mR/hr @ 1 meter on 9-20-82 as determined by NIST.
3. 137-5.5-1 was 150 mR/hr @ 1 meter on 9-20-82 as determined by NIST.

DOE Studies

Fermilab's ES&H Section participated in a DOE Radiological Calibration Intercomparison Program in January, 1987[8] and again in April, 1992[9]. The detector

sensitivities calculated from our source calibration vs. the sensitivity determined by PNL are shown in Table 2. The results of this study provide us with a coarse indicator of our source calibration consistency with other DOE facilities.

The large discrepancy in the 1987 data (vs. PNL's sensitivity) for the GM counter cannot be explained. However, the 1987 test was conducted primarily by summer employees with less experience with the equipment and data acquisition.

Table 2

Gamma Source Measurement Detector Sensitivities from

The DOE Radiological Calibration Intercomparison Program.

Date Performed	7/87		4/92		
Detector Used	GM Counter	PM-30	GM Counter	PM-30	TEIC
Meas. Units	R/Pulse	R/Coulomb	R/Pulse	R/Coulomb	R/Coulomb
PNL Detector Sensitivity	6.17×10^{-7}	1×10^{8}	6×10^{-7}	1×10^{8}	3×10^{6}
Source I.D.					
137-3.5-1 NIST			6.17×10^{-7}		3.034×10^{6}
137-5.4-2 OLD NBS REF.	4.55×10^{-7}				
137-6.1-1		1.13×10^{8}	6.1×10^{-7}	1.129×10^{8}	
137-7.1-1		1.11×10^{8}	6.18×10^{-7}	1.111×10^{8}	
137-8.1-1		1.10×10^{8}		1.125×10^{8}	

Conclusion

ANSI N323-1978[4] discussion of calibration sources specifies that the uncertainty of the calibration of these sources shall be no greater than +/- 2% with respect to U.S. National Standards. Reference class (cable connected) instrumentation and NIST traceable temperature and barometeric pressure measuring devices must be purchased to obtain accuracy at the +/- 2% level.

REFERENCES

1. National Bureau of Standards, Report of Calibration, Test No. 198100(1 & 2), NBS No. 47403, NBS, 1969.

2. U.S. Department of Commerce, National Bureau of Standards, Report of Calibration, DG 7989/82, DB 806:188-190, TFN 228916, NBS, 1982.

3. U.S. Department of Commerce, National Bureau of Standards, Report of Calibration, DG 7988/82, DB 806:188-190, TFN 228916, NBS, 1982.

4. ANSI N323-1978, American National Standard Radiation Protection Instrumentation Test and Calibration, Approved 9/13/77, Health Physics Society and I.E.E.E. Inc., U.S.A..

5. Krueger, F., RP Note 89, Operation of Instrumentation Used for Gamma Ray Source Transfer Calibration and Facility Studies, Fermilab, 1992.

6. Krueger, Larson, Ruhe; RP Note 51, Site 68 Source Projector Facility Project Summary; Fermilab, 1985.

7. U.S. Department of Commerce, National Bureau of Standards, Report of Calibration, Victoreen R-Meter, DG 7612/80, TFN 224479, NBS, 1981.

8. Dagenais, Sanchez, Allen; RP Note 66; DOE Radiological Calibrations Intercomparison Program: Fermilab Participation; Fermilab, 1987.

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